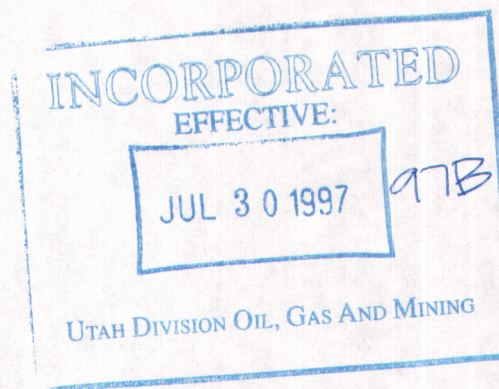


APPENDIX 3-11

**SPRUCE/FIR/ASPEN COMMUNITIES
AT THE CRANDALL CANYON MINE - 1996**

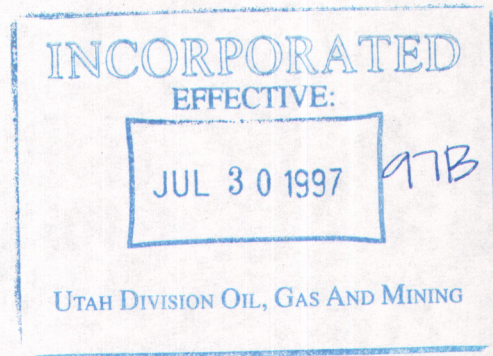
FEBRUARY 1997



***SPRUCE/FIR/ASPEN COMMUNITIES
AT THE
CRANDALL CANYON MINE***

1996





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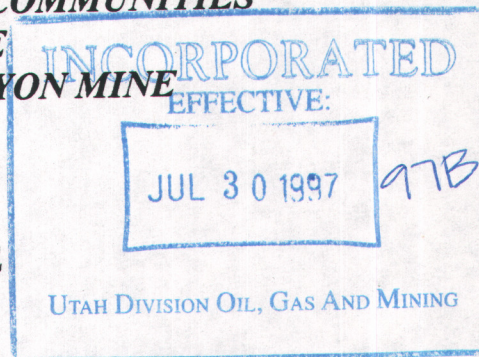
UTAH DIVISION OIL, GAS AND MINING

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SPRUCE/FIR/ASPEN COMMUNITIES

**AT THE
CRANDALL CANYON MINE**



SCOPE

The following report has been written in an attempt to assess the current condition of a plant community that has been proposed for future disturbance by a coal mining company. A reference area chosen in a similar plant community has also been studied that will be used as a standard for future revegetation success. Finally, an area that has been previously disturbed by natural conditions has also been reported in this document.

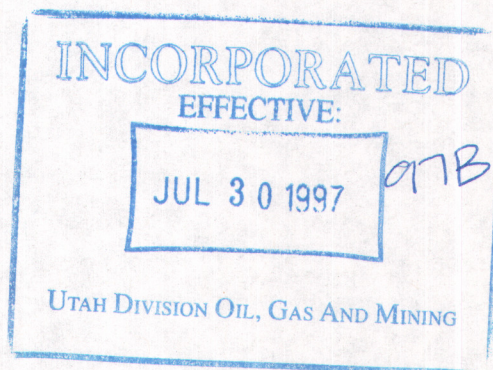
INTRODUCTION

General Site Description

Genwal Coal Company's Crandall Canyon Mine is situated within Crandall Canyon, a tributary of Huntington Canyon. These canyons are located within a portion of the Wasatch Plateau in Emery County, Utah.

An area has been proposed for disturbance to accommodate expansion of the coal mine's surface facilities. The proposed area would primarily affect riparian and spruce/fir/aspen plant communities. Also affected could be another plant community that, because of natural erosion and subsequent small earth slides, the species composition has been somewhat changed and represents more disturbed or transitional plant species. A reference area was also chosen to be used as a standard for future revegetation success. This area is located in the same general area, but at a slightly higher elevation and will not be disturbed by future mining activities. Mitigation of the riparian area has already been planned and approved, so this plant community was not sampled for this report.

The reference and proposed disturbance areas had very similar environmental characteristics i.e. soils, geology, aspect, slope, elevation, climate and vegetation. Elevation of the study areas ranged between 7,500 ft and 8,000 ft above sea level. Exposure was primarily north-facing with a slope of 38 degrees on both the proposed disturbed and reference areas.



METHODS

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Methodologies used herein were performed in accordance with the guidelines supplied by the State of Utah, Division of Oil, Gas and Mining (DOGM).

Quantitative and qualitative data were recorded within the plant communities of the proposed disturbed and reference areas in Crandall Canyon in July 1996.

Transect and Quadrat Placement

Transect lines for sampling were placed randomly throughout the sample areas. Stratified random placement of sampling quadrats were designed to decrease bias, yet encompass as much of the area as practical. Once the transect lines were placed, regular points were then marked on them. From these marks, a random number dictated the direction and distance to place the quadrats at right angles to the transect lines.

Cover, Composition and Frequency

Cover estimates were made using ocular methods with meter square quadrats. Two methods were employed for cover estimates. First, the cover was estimated so that, with the structural layering (or foliage height diversity) of the plant species including rock

litter and bareground, there was a possibility of reaching total cover that exceeded 100 percent. In this method the actual ground cover was first estimated, disregarding cover created by forest canopy. Overstory was then estimated, adding it the ground cover. The second method ignored structural layering so that total cover including overstory, understory, litter, rock and bareground summed to be exactly 100 percent. Although both methods are acceptable in concept, each focuses on slightly different composition and/or wildlife habitat. Data from the later methods (where total cover summed to 100 percent) were reported within the context of this document.

Species composition, or the relative percent of each life form, were calculated from the cover data. Additionally, relative frequencies, or the relative number each plant species was present in the quadrats, were also assessed.

Additional information recorded on the raw data sheets were: estimated precipitation, slope, exposure, grazing use, animal disturbance and other appropriate notes. Plant nomenclature followed "A Utah Flora" (Welsh et al., 1993).

Woody Plant Species Density

Density of woody plant species in all areas were recorded using the point-quarter distance method developed by Cottom and Curtis

in 1956. In this method, random points were placed on the sample sites and measured into four quarters. The distances to the nearest woody plant species were then recorded in each quarter. The average point-to-individual distance was equal to the square root of the mean area per individual.

Sample Adequacy & Statistical Comparisons

Sampling adequacy was attempted using formulas from Cochran (1977), with the goal that at least 80% of the samples would fall within 10% of the true mean for the plant communities in the area. The formula used is given below.

$$N_{\min} = \frac{t^2 s^2}{(dx)^2}$$

where,

N_{\min}	= minimum adequate sample
t	= appropriate confidence t-value
s	= standard deviation
x	= sample mean
d	= desired change from mean

Student's t-tests were also employed to compare the proposed disturbed and reference areas of the sites for cover and density. All sample means, standard deviations, and sample sizes were included in this report to enable the reviewers to check or apply further statistical tests if desired.

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Photographs

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Color photographs of the sample areas were taken at the time of sampling and have been submitted with this report.

RESULTS

Proposed Disturbed (Spruce/Fir/Aspen)

The total living cover of the area proposed for disturbance was estimated at 78.75% (shown in Table 7), of which 42.25% consisted of overstory cover and 36.50% was understory [see Table 1(A)]. The remainder of the ground cover was litter (13.39%), bareground (4.09%) and rock (3.76%). Composition of the understory cover consisted of 89.33% woody species, 8.64% forbs and 2.03% grasses [Table 1(B)].

Most common overstory species were Douglas fir (*Pseudotsuga menziesii*) and Colorado blue spruce (*Picea pungens*), including limited aspen (*Populus tremuloides*) trees. The color photographs in this report show this community well. Most prevalent understory woody species were: soapberry (*Sheperdia canadensis*), mountain lover (*Pachistima myrsinites*), Red-osier dogwood (*Cornus sericea*), and Douglas fir [see Table 1(C)].

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Although much less abundant than the woody species, several forbs were present in the quadrats. Some of the more common species were baneberry (*Actaea rubra*), blueleaf aster (*Aster glaucodes*) and blunt-fruit sweet-cicely (*Osmorhiza depauperata*). Only two grass species were present in the plots -- Kentucky bluegrass (*Poa pratensis*) and mountain brome (*Bromus carinatus*).

Woody species density was quite high, estimated at 11,990 individuals per acre. Most of the common species in the density measurements were nearly the same as reported above in the cover information. Refer to Table 2 for the density of all woody species.

Reference Area (Spruce/Fir/Aspen)

The area chosen as a reference area to be used for future revegetation success standards had nearly identical total living cover (75.25%) as the proposed disturbed area, but the proportion of overstory (30.50%) and understory (44.75%) was somewhat different [Table 3(A)]. Litter, bareground and rock cover were also similar to the proposed disturbed area.

Understory composition was also similar in the understory species but the reference area had slightly more grasses and forbs proportionately [Table 3 (B)]. Moreover, the dominant species of the reference area were very similar to the proposed disturbed

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area [Table 3 (C)]. Woody species density was even higher in this area, estimated at over 15,000 individuals per acre (Table 4).

Previously Disturbed

Other areas that are proposed for disturbance were probably once very similar to the communities reported above, but due to soil conditions, steep slopes, and excess moisture these areas have been subject to small earth slides or "sloughing". Consequently, the plant cover and composition in these areas of natural disturbance were rather different than the previously described communities. For this reason these areas were sampled, documented, photographed, and reported separately.

No overstory was present in these area. Total living cover (understory) was estimated as 29.58. Litter only comprised 8.75%, whereas rock and bareground were both nearly 31.0% [Table 5 (A)]. Composition was also somewhat different when compared to the areas reported above. For example, relatively few woody species were encountered within the quadrats (9.41%). Forbs were the most prevalent life form (75.40%), followed distantly by grasses (15.19%). Refer to Table 5(B) for composition figures.

As one would expect by the comments above, the most common species were also quite different than the reference and proposed

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disturbed areas. The most common species was blueleaf aster, followed by thistle (*Cirsium* sp.) and mountain brome [Table 5(C)].

Woody species density was also markedly different. Total number of individuals per acre was only 1,718, the most common being snowberry (*Symphoricarpos oreophilus*), Woods rose (*Rosa woodsii*) and current (*Ribes wolfii*). Refer to Table 6 for woody species densities of each species.

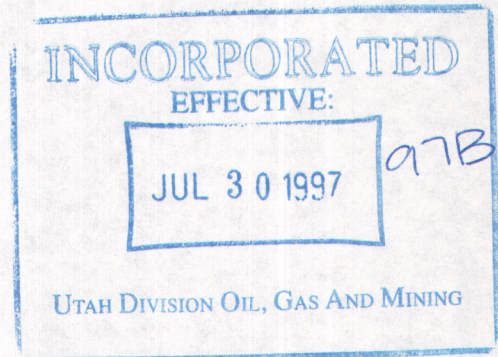
DISCUSSION

Statistical Comparisons

Each parameter of the proposed disturbed area was compared to those of the reference area. With the exception of the previously disturbed or slide areas, most of the parameters were very similar. For example, when the total living cover (overstory and understory) were compared, there was no statistical difference between the two areas. Furthermore, there was no difference in the understory comparison, however, the overstory cover was statistically greater in the proposed disturbed area (this was unusual due to the close similarities between understory and total living cover). Density did show a difference statistically with more woody plants per acre in the

reference area.

Standards for Revegetation Success

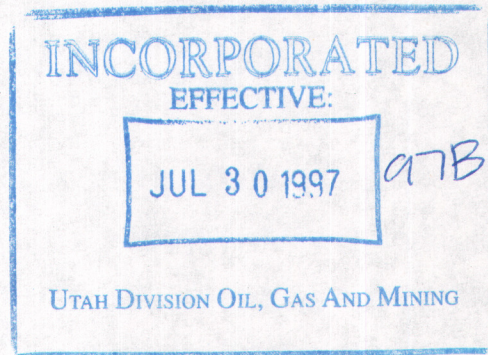


For the most part, most of the area proposed for disturbance compared quite favorably with the reference area selected to be the standard at the time of final reclamation.

One could use the total living cover for the cover standard, but at values approaching 80%, this may be difficult to achieve at the time of final reclamation. This, because approximately half of this cover value was contributed by overstory, and it is unlikely that the revegetated communities will be mature enough to provide this much overstory in the 10-year responsibility period required for the mined land reclamation. On the other hand, understory values alone may not be an aggressive enough standard of success for cover. An intermediate value could be considered.

Consideration should also be given to using standards of success for density as high as the estimated values suggest. Obviously, the dense stands of woody species comes at the expense of forbs and grasses that may provide valuable wildlife habitat diversity. In other words, more native forb and grass species cover may be more desirable to provide habitat diversity.

Finally, the standards for the previously disturbed areas should be set no higher than what currently exists. However, consideration could also be entertained to making the standards the same in these areas as those of the proposed disturbed areas if the aforementioned *intermediate* values are agreed upon by the mining company and DOGM.



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TABLE 1: Summary of total cover, composition and cover by species for the **Proposed Disturbed Spruce/Fir/Aspen Community** in Crandall Canyon, Utah.

UTAH DIVISION OIL, GAS AND MINING

A.

TOTAL COVER	% MEAN COVER	STANDARD DEVIATION	SAMPLE SIZE
Overstory Cover	42.25	15.53	20
Understory Cover	36.50	12.36	20
Litter	13.39	8.46	20
Bareground	4.09	5.50	20
Rock	3.76	3.24	20

B.

UNDERSTORY COMPOSITION	PERCENT	STANDARD DEVIATION	SAMPLE SIZE
Trees & Shrubs	89.33	21.56	20
Forbs	8.64	16.67	20
Grasses	2.03	6.55	20

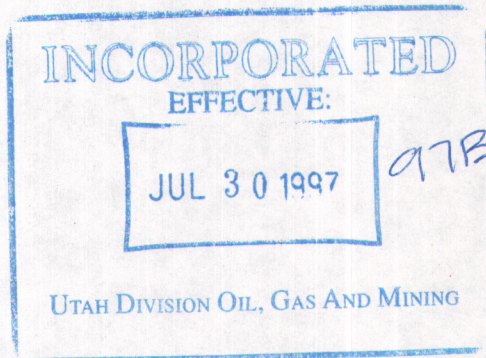
C.

UNDERSTORY COVER & FREQ. BY SPECIES	% MEAN COVER	STANDARD DEVIATION	SAMPLE SIZE	RELATIVE FREQUENCY
<u>Trees & Shrubs</u>				
<i>Acer glabra</i>	0.50	2.18	20	5.00
<i>Cornus sericea</i>	5.00	9.75	20	35.00
<i>Jumiperus communis</i>	0.50	2.18	20	5.00
<i>Lonicera utahensis</i>	0.25	1.09	20	5.00
<i>Pachistima myrsinites</i>	5.50	6.87	20	50.00
<i>Picea pungens</i>	1.00	3.00	20	10.00
<i>Populus tremuloides</i>	1.25	2.68	20	15.00
<i>Pseudotsuga menziesii</i>	4.00	7.00	20	35.00
<i>Rosa woodsii</i>	0.50	2.18	20	5.00
<i>Salix lutea</i>	0.50	2.18	20	5.00
<i>Shepherdia canadensis</i>	12.75	15.81	20	75.00
<i>Symphoricarpos oreophilus</i>	1.50	4.50	20	15.00
<u>Forbs</u>				
<i>Actaea rubra</i>	0.50	1.50	20	10.00
<i>Aster glaucodes</i>	0.50	1.50	20	10.00
<i>Fragaria vesca</i>	0.15	0.65	20	5.00
<i>Gentianella heterosepala</i>	0.15	0.65	20	5.00
<i>Geranium richardsonii</i>	0.25	1.09	20	5.00
<i>Lathrus lanszwertii</i>				
<i>Osmorhiza depauperata</i>	0.50	2.18	20	5.00
<i>Smilacina stellata</i>	0.25	1.09	20	5.00
<i>Swertia radiata</i>	0.35	1.15	20	10.00
<u>Grasses</u>				
<i>Bromus carinatus</i>	0.10	0.44	20	5.10
<i>Poa pratensis</i>	0.50	1.50	20	10.00

TABLE 2: Summary for woody species density for the **Proposed Disturbed** Spruce/Fir/Aspen Community in Crandall Canyon, Utah.

A.

WOODY SPECIES DENSITY	NUMBER/ACRE
<i>Acer glabra</i>	149.87
<i>Acer grandidentatum</i>	149.87
<i>Cornus sericea</i>	1948.36
<i>Juniperus communis</i>	149.87
<i>Lonicera utahensis</i>	149.87
<i>Pachistima myrsinites</i>	2997.48
<i>Picea pungens</i>	299.75
<i>Populus tremuloides</i>	599.50
<i>Pseudotsuga menziesii</i>	1798.48
<i>Ribes wolfii</i>	1798.49
<i>Rosa woodsii</i>	749.37
<i>Salix lutea</i>	149.87
<i>Rubus parviflorus</i>	149.87
<i>Shepherdia canadensis</i>	599.50
<i>Symphoricarpos oreophilus</i>	299.75
TOTAL	<u>11989.92</u>



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TABLE 3: Summary of total cover, composition and cover by species for the
Reference Area Spruce/Fir/Aspen Community in Crandall Canyon, Utah.

UTAH DIVISION OIL, GAS AND MINING

A. TOTAL COVER	% MEAN COVER	STANDARD DEVIATION	SAMPLE SIZE	
Overstory Cover	30.50	19.93	20.00	
Understory Cover	44.75	20.09	20.00	
Litter	14.12	7.45	20.00	
Bareground	6.02	4.53	20.00	
Rock	4.61	3.07	20.00	
B. UNDERSTORY COMPOSITION	PERCENT	STANDARD DEVIATION	SAMPLE SIZE	
Trees & Shrubs	84.16	17.04	20.00	
Forbs	11.23	14.02	20.00	
Grasses	4.60	7.37	20.00	
C. UNDERSTORY COVER & FREQ. BY SPECIES	% MEAN COVER	STANDARD DEVIATION	SAMPLE SIZE	RELATIVE FREQUENCY
<u>Trees & Shrubs</u>				
<i>Abies concolor</i>	2.75	7.82	20	20.00
<i>Lonicera utahensis</i>	2.50	8.87	20	10.00
<i>Mahonia repens</i>	0.25	1.09	20	5.00
<i>Pachistima myrsinites</i>	10.00	13.69	20	40.00
<i>Picea pungens</i>	0.50	2.18	20	5.00
<i>Populus tremuloides</i>	2.50	4.87	20	30.00
<i>Pseudotsuga menziesii</i>	4.25	6.53	20	45.00
<i>Ribes wolfii</i>	7.75	7.33	20	80.00
<i>Rosa woodsii</i>	0.90	1.84	20	20.00
<i>Salix lutea</i>	0.25	1.09	20	5.00
<i>Sambucus caerulea</i>	0.50	2.18	20	5.00
<i>Shepherdia canadensis</i>	4.25	7.79	20	35.00
<i>Symphoricarpos oreophilus</i>	2.00	3.67	20	25.00
<u>Forbs</u>				
<i>Achillea millefolium</i>	0.10	0.44	20	5.00
<i>Aster glaucodes</i>	2.25	2.95	20	40.00
<i>Castilleja</i> sp.	0.15	0.65	20	5.00
<i>Lathrus lanszwertii</i>	0.25	1.09	20	5.00
<i>Smilacina stellata</i>	0.50	1.50	20	10.00
<i>Swertia radiata</i>	0.85	1.80	20	20.00
<i>Thalictrum fendleri</i>	0.25	1.09	20	5.00
<u>Grasses</u>				
<i>Bromus carinatus</i>	1.00	2.00	20	20.00
<i>Poa pratensis</i>	1.00	2.00	20	20.00

TABLE 4: Summary for woody species density for the **Reference Area**
Spruce/Fir/Aspen Community in Crandall Canyon, Utah.

A.

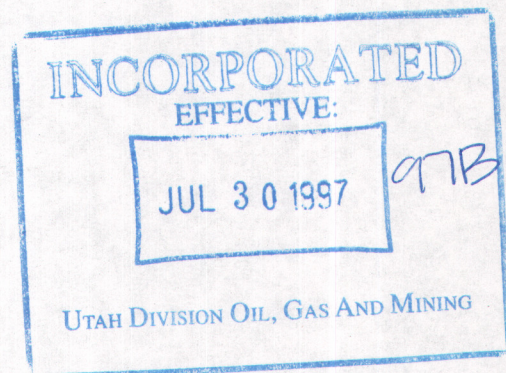
WOODY SPECIES DENSITY

NUMBER/ACRE

<i>Abies concolor</i>	1125.73
<i>Lonicera utahensis</i>	562.86
<i>Mahonia repens</i>	187.62
<i>Pachistima myrsinites</i>	1500.97
<i>Populus tremuloides</i>	3001.94
<i>Pseudotsuga menziesii</i>	938.10
<i>Ribes wolfii</i>	3377.18
<i>Rosa woodsii</i>	750.48
<i>Salix lutea</i>	187.62
<i>Shepherdia canadensis</i>	2439.07
<i>Symphoricarpos oreophilus</i>	938.11

TOTAL

15009.68



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TABLE 5: Summary of total cover, composition and cover by species for the
Previously Disturbed Spruce/Fir/Aspen Community in Crandall Canyon, Utah.

UTAH DIVISION OIL, GAS AND MINING

A.

TOTAL COVER	% MEAN COVER	STANDARD DEVIATION	SAMPLE SIZE
Overstory Cover	--	--	12
Understory Cover	29.58	9.46	12
Litter	8.75	9.60	12
Bareground	30.83	18.47	12
Rock	30.83	11.70	12

B.

UNDERSTORY COMPOSITION	PERCENT	STANDARD DEVIATION	SAMPLE SIZE
Trees & Shrubs	9.41	14.57	12
Forbs	75.40	25.14	12
Grasses	15.19	16.78	12

C.

UNDERSTORY COVER & FREQ. BY SPECIES	% MEAN COVER	STANDARD DEVIATION	SAMPLE SIZE	RELATIVE FREQUENCY
<u>Trees & Shrubs</u>				
<i>Pachistima myrsinites</i>	0.42	1.38	12	8.33
<i>Populus tremuloides</i>	0.42	1.38	12	8.33
<i>Ribes wolfii</i>	0.83	1.86	12	16.67
<i>Rosa woodsii</i>	1.25	2.98	12	16.67
<u>Forbs</u>				
<i>Achillea millefolium</i>	1.25	2.17	12	25.00
<i>Aster glaucodes</i>	6.67	4.71	12	83.33
<i>Castilleja</i> sp.	0.83	1.86	12	16.67
<i>Cirsium</i> sp.	3.75	3.61	12	35.00
<i>Epilobium angustifolium</i>	0.83	1.86	12	16.67
<i>Gentianella heterosepala</i>	2.50	2.50	12	50.00
<i>Geranium richardsonii</i>	2.92	4.77	12	33.33
<i>Lathrus lanszwertii</i>	0.83	1.86	12	16.67
<i>Senecio eremophilus</i>	0.83	1.86	12	16.67
<i>Swertia radiata</i>	1.25	2.17	12	25.00
<u>Grasses</u>				
<i>Bromus carinatus</i>	3.33	5.14	12	33.33
<i>Poa pratensis</i>	1.67	3.12	12	25.00

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TABLE 6: Summary for woody species density for the **Previously Disturbed**
Spruce/Fir/Aspen Community in Crandall Canyon, Utah.

UTAH DIVISION OIL, GAS AND MINING

A.

WOODY SPECIES DENSITY

NUMBER/ACRE

<i>Acer glabra</i>	143.18
<i>Pachistima myrsinites</i>	35.80
<i>Picea pungens</i>	71.59
<i>Ribes wolfii</i>	357.95
<i>Rosa woodsii</i>	429.54
<i>Shepherdia canadensis</i>	143.18
<i>Symphoricarpos oreophilus</i>	<u>536.93</u>

TOTAL

1718.17

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TABLE 7: Statistical summary sheet for the proposed disturbed and reference areas in Crandall Canyon, Utah

UTAH DIVISION OIL, GAS AND MINING

PROPOSED DISTURBED

Overstory Cover	x=42.25	s=15.53	n=20
Understory Cover	x=36.50	s=12.36	n=20
Total Living Cover*	x=78.75	s=9.47	n=20
Density**	x=523.16	s=220.35	n=20

REFERENCE AREA

Overstory Cover	x=30.50	s=19.93	n=20
Understory Cover	x=44.75	s=20.09	n=20
Total Living Cover*	x=75.25	s=7.15	n=20
Density**	x=417.91	s=159.80	n=20

PREVIOUSLY DISTURBED

Overstory Cover	x= --	s= --	n=12
Understory Cover	x=29.58	s=9.46	n=12
Total Living Cover*	x=29.58	s=9.46	n=12
Density**	x=3650.78	s=1808.33	n=12

STATISTICAL ANALYSES

Proposed Disturbed vs. Reference Area

Overstory Cover	t=2.080	df=38	SL=p<.05
Understory Cover	t=1.564	df=38	SL=NS
Total Living Cover	t=1.319	df=38	SL=NS
Density	t=1.729	df=38	SL=p<.05

Previously Disturbed vs. Reference Area

Overstory Cover	t= --	df= --	SL= --
Understory Cover	t=2.446	df=30	SL=p<.05
Total Living Cover	t=15.491	df=30	SL=p<.05
Density	t=8.031	df=30	SL=p<.05

x = sample mean, s = sample standard deviation,

n = sample size, NS = nonsignificant,

p = probability level of significance

* represents understory and overstory cover combined.

** represents average space (sq. in.) occupied by each individual (see Tables for actual density measurements).



COLOR PHOTOGRAPHS

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Reference Area (Spruce/Fir/Aspen)

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MINING



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Previously Disturbed Area

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MINING



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Proposed Disturbed (Spruce/Fir/Aspen)

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